(12) UK Patent Application (19) GB (11) 2 241 349 (13) A

(43) Date of A publication 28.08.1991

(21) Application No 8923995.8

(22) Date of filing 25.10.1989

(71) Applicant
STC PLC

(Incorporated in the United Kingdom)

~~1B Portland~~ Place, London, W1N 3AA, United Kingdom

(72) Inventor
Adrian Perrin Janssen

(74) Agent and/or Address for Service
S F Laurence
STC Patent Department, West Road, Harlow, Essex, CM20 2SH, United Kingdom

(51) INT CL[5]
G02B 6/32, B29C 45/14

(52) UK CL (Edition K)
G2J JGEB JG2
B5A AB20 A1R214B A1R314C1D A1R314C1F A1R314C6 A20T14

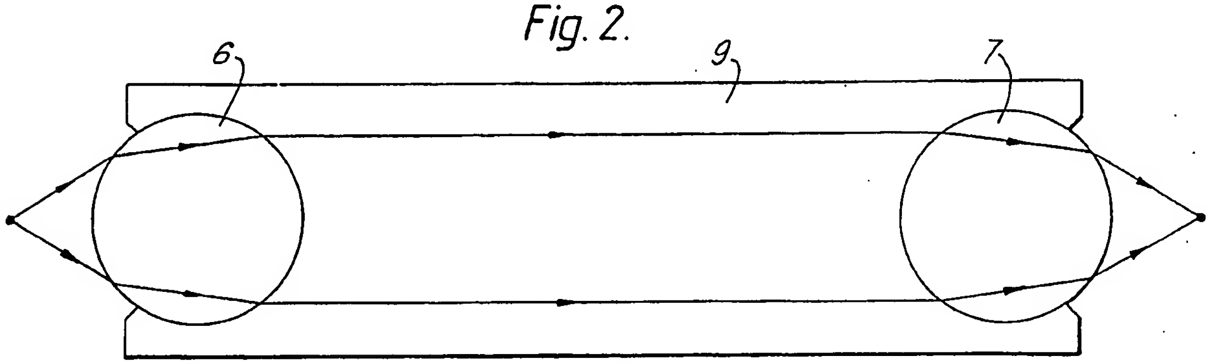
(56) Documents cited
GB 2002136 A   EP 0226881 A2

(58) Field of search
UK CL (Edition J) B5A AB10 AB20, G2J JGEB JGED
INT CL[4] B29C, G02B

(54) **Lens assembly**

(57) A lens assembly for coupling an optical fibre and an electro-optic transducer providing a low cost substitute for a small diameter graded index lens is provided by a transparent plastics body member (9) in two opposed ends of which are housed first and second spherical ball lenses (6, 7).

Fig. 2.



GB 2 241 349

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

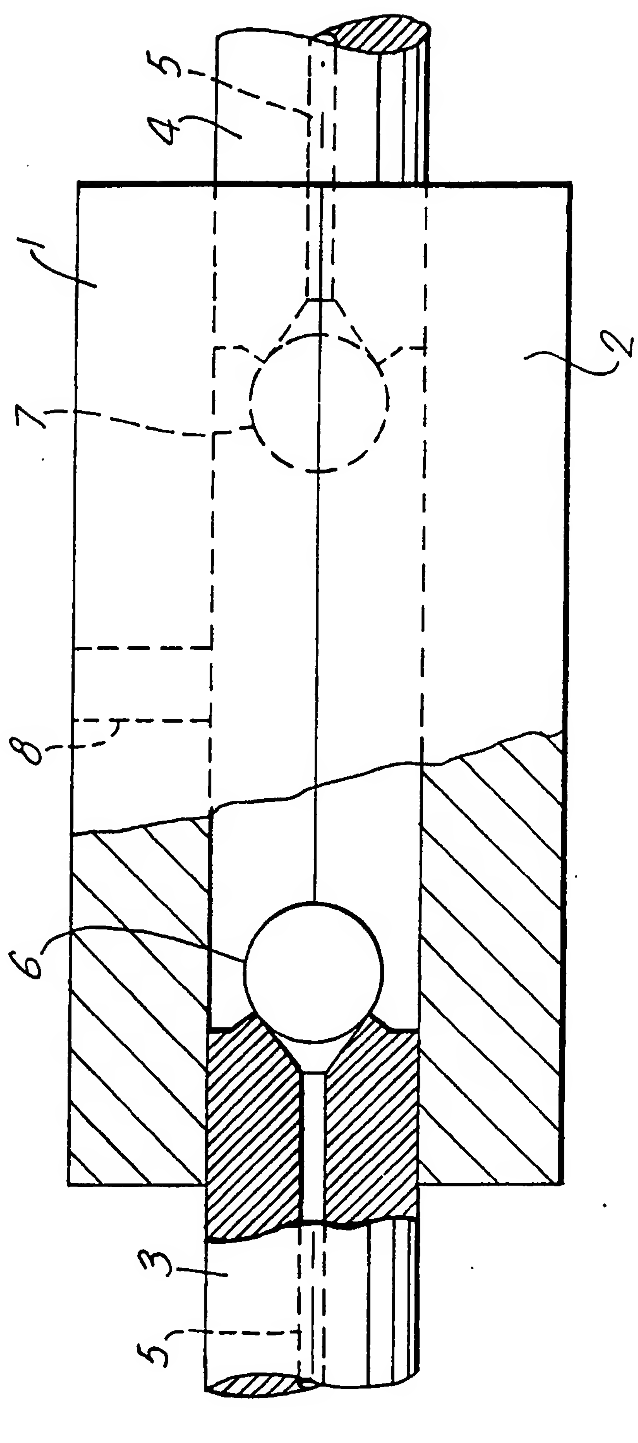


Fig.1.

Fig. 2.

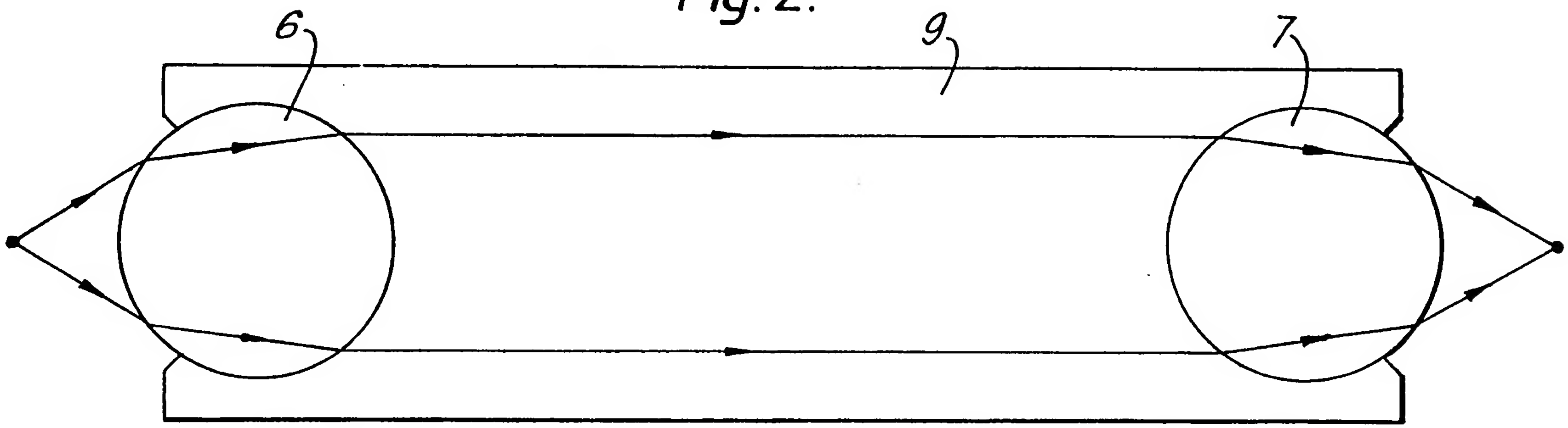
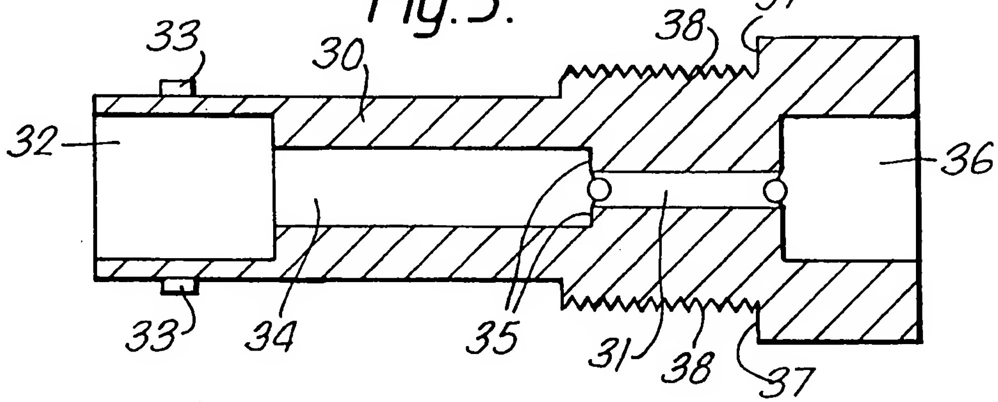


Fig. 3.



LENS ASSEMBLY

This invention relates to lens assemblies, one particular application for which is as a substitute for a graded index (GRIN) lens.

Many applications in fibre-optics require optical coupling for instance between the end of an optical waveguide, typically an optical-fibre, and an optical source or detector, and such optical coupling is frequently effected by means of a small lens. In some instances a single spherical ball lens constitutes a satisfactory coupling element, but in other instances the required minimum spacing between the elements to be coupled by the lens is too great for single ball lens of a practical size. In these instances a solution that may be optically satisfactory is to provide the optical coupling by means of a GRIN lens. A drawback of this approach is the relatively high intrinsic cost of GRIN lenses that results from the fact that carefully controlled diffusion processes are involved in their manufacture. The present invention is directed to a lens assembly design that is intrinsically cheaper to make.

According to the present invention there is provided a lens assembly having a body member holding first and second spherical ball lenses which provide the

refracting surfaces at the two ends of the lens assembly.

In respect of lens assemblies designed for use in the infra-red region of the spectrum, the ball lenses and the plastics body member are of course required to be transparent in the relevant region of the infra-red, but do not have to be transparent in the visible region of the spectrum. Generally, however, it is preferred for the transparency, at least of the plastics body member, to extend into the visible in order to facilitate inspection for defects such as bubbles or other adventitious inclusions within the body member. Normally the two ball lenses of a lens assembly are made of the same material. They may be of the same size, but are not necessarily so, and indeed the use of balls of different size may generally be preferred in situations calling for magnification factors significantly different from unity.

There follows a description of a method of making lens assemblies embodying the invention in preferred forms, and of a specific lens assembly incorporated as part of a connector for coupling an optical fibre to an electro-optic transducer.

The description refers to the accompanying drawings in which:-

Figure 1 depicts injection moulding tooling for making a lens assembly,

Figure 2 depicts a lens assembly made using the tooling of Figure 1, and

Figure 3 depicts a logitudinal section through a connector incorporating the lens assembly of Figure 2.

Referring to Figure 1, the preferred method of making a lens assembly according to the present

invention is by injection moulding using tooling that comprises a pair of main body halves 1 and 2 and two end members 3 and 4. The two main body halves, when assembled, define a cylindrical moulding space whose ends are closed off by the end members 3 and 4. Each end member has a central bore 5 additionally functioning as a vacuum pick-up tool for holding a ball lens 6, 7 in position in the tooling. Application of a vacuum to the central bore 5 in the end member serves to hold the ball lens firmly in position against a seating that prevents moulding compound from leaking round the ball and out through the central bore of the end member. Typically the ball lenses 6, 7 lie in the range from 0.2 to 2.0mm, and are made of high optical quality material such as glass, sapphire or zirconia. The moulding material, which is introduced into the tooling by way of an aperture 8, may be for example polystyrene, a polycarbonate, or an acrylate. As an alternative to injection moulding, the two ball lenses may be located in the opposite ends of a cylinder of casting resin such as an epoxy resin.

A feature of these lens assemblies is the relative simplicity and cheapness of their method of manufacture compared with the manufacture of other forms of lens assembly of similar proportions. Unlike GRIN lenses there is no requirement to perform a relatively time-consuming and critical diffusion process. Ball lenses are readily available and relatively cheap, thus making the manufacturing process of the lens assembly cheap compared with the manufacture of an all-glass monolithic equivalent structure. The use of ball lenses also avoids the problems, encountered in the manufacture of all-plastics lenses, of moulding the refracting surfaces to the required dimensional tolerance and stability. Additionally it is relatively easy to modify the manufacturing process so as to change the overall length of the lens assembly, or to change the design to

one employing a different size of ball lens.

A specific example of lens assembly depicted in Figure 2 is designed to provide unit magnification with a focus-to-focus distance of approximately 8.8mm at a wavelength of 1300nm. This comprises a pair of sapphire 1.5mm diameter ball lenses 6, 7 located at opposite ends of a generally cylindrically-shaped acrylate moulding 9 having a refractive index of approximately 1.45. The overall length of the lens system is approximately 7.5mm. Optionally the two ball lenses are provided with anti-reflection coatings.

One application for such lens assemblies is for effecting optical coupling in a long-barrelled optical connector between the end of a ferrule-terminated optical fibre and a can-packaged electro-optic source or detector. For some connector applications a short-barrelled connector can be employed in which the end of the fibre can be brought up close to the can window as to lie in the vicinity of the image of the active area of the transducer formed just outside the can window. In other applications, however, the end of the fibre can not be brought so close to the can and a lens coupling is required. Close approach may for instance be prevented because the connector barrel must be long enough to penetrate a bulkhead and be adequately secured to it. At the same time other considerations may dictate that the transducer must be mounted a certain distance behind this bulkhead, for instance to provide short terminal connections between the transducer and its driver.

Figure 3 depicts a long-barrelled optical connector 30 incorporating a lens assembly 31 as described above with reference to Figures 1 and 2. The connector 30 is a generally tubular structure. At one end there is a chamber 32 for receiving the connector

locking member (not shown) of a ferrule-terminated optical fibre (not shown). When this locking member is engaged around two bayonet studs 33 it urges the ferrule termination into a receiving chamber 34, forward movement being arrested by a shoulder 35. Communicating with the receiving diameter 34 is a smaller diameter bore in which the lens assembly 31 is secured either mechanically or with adhesive. This bore opens out into a larger chamber 36 dimensioned to receive the electro-optic transducer can (not shown), typically a TO 46 can. The connector body is provided with an external forward-facing shoulder 37 and an externally threaded portion 38 on which a nut (not shown) may be engaged for securing the assembly in an aperture in a bulkhead (not shown).

In the case of a long-barrelled connector designed for optically coupling a ferrule-terminated optical fibre with a semiconductor laser, the lens assembly may be arranged, not to give unit magnification, but about a fourfold magnification in order to provide a closer match between the emission solid-angle of the laser and the acceptance solid angle of the fibre.

CLAIMS.

1. A lens assembly having a body member holding first and second spherical ball lenses which provide the refracting surfaces at the two ends of the lens assembly.

2. A lens assembly as claimed in claim 1 wherein the first and second ball lenses are of the same size.

3. A lens assembly as claimed in claim 1 or 2 wherein the body member is an injection moulded plastics member.

4. A lens assembly substantially as hereinbefore described with reference to the accompanying drawings.

5. A method of making a lens assembly in which method two spherical ball lenses are moulded in to the opposite ends of a body of transparent plastics material to provide the refracting surfaces at the two ends of the lens assembly.

6. A method as claimed in claim 5 wherein the two ball lenses are moulded in by injection moulding.

7. A method of making a lens assembly which method is substantially as hereinbefore described with reference to Figures 1 of the accompanying drawings.

8. A lens assembly made by the method of claim 5, 6, or 7.

9. An optical connector for providing optical coupling between an optical waveguide and an electro-optic transducer or further waveguide, which connector incorporates a lens assembly as claimed in claim 1, 2, 3, 4 and 8.

Amendments to the claims have been filed as follows

CLAIMS.

1. A lens assembly having an injection moulded plastics body member holding first and second spherical ball lenses which provide the refracting surfaces at the two ends of the lens assembly.

2. A lens assembly as claimed in claim 1 wherein the first and second ball lenses are of the same size.

3. A lens assembly substantially as hereinbefore described with reference to the accompanying drawings.

4. A method of making a lens assembly in which method two spherical ball lenses are moulded in to the opposite ends of a body of transparent plastics material to provide the refracting surfaces at the two ends of the lens assembly.

5. A method as claimed in claim 4 wherein the two ball lenses are moulded in by injection moulding.

6. A method of making a lens assembly which method is substantially as hereinbefore described with reference to Figures 1 of the accompanying drawings.

7. A lens assembly made by the method of claim 4, 5, or 6.

8. An optical connector for providing optical coupling between an optical waveguide and an electro-optic transducer or further waveguide, which connector incorporates a lens assembly as claimed in claim 1, 2, 3, or 7.